



What is claimed is:

- 1 1. A fast steering mirror, comprising:
2 a base member;
3 an outer gimbal, pivotally coupled to the base member;
4 an inner gimbal, pivotally coupled to the outer gimbal;
5 a mirror fixedly coupled to the inner gimbal;
6 a first pair of voice coil drivers comprising a first pair of magnetized stators
7 fixedly coupled to the base member and a first pair of voice coils fixedly coupled to
8 the outer gimbal; and
9 a second pair of voice coil drivers comprising a second pair of magnetized
10 stators fixedly coupled to the base member and a second pair of voice coils fixedly
11 coupled to the inner gimbal.
- 1 2. The fast steering mirror of claim 1, wherein each of said first and second pair
2 of voice coils comprise a cylindrical shell-shaped bobbin having a plurality of
3 conductive coils wound around an external portion thereof.
- 1 3. The fast steering mirror of claim 1, wherein each of said first and second pair
2 of magnetized stators comprise a generally can-shaped member made of a
3 magnetically permeable material in which an annular magnet is disposed.

1 4. The fast steering mirror of claim 3, wherein the generally can-shaped
2 member further comprises an internal post extending upward from a base portion
3 thereof.

1 5. The fast steering mirror of claim 1, wherein the outer gimbal includes a pivot
2 axis and is configured such that the outer gimbal and the first pair of voice coils
3 fixedly coupled thereto have a combined center of gravity through which the pivot
4 axis substantially passes.

1 6. The fast steering mirror of claim 1, wherein the inner gimbal includes a pivot
2 axis and is configured such that the outer gimbal and the second pair of voice coils
3 fixedly coupled thereto have a combined center of gravity through which the pivot
4 axis substantially passes.

1 7. The fast steering mirror of claim 1, wherein the outer gimbal has a first pivot
2 axis and the inner gimbal has a second pivot axis that is substantially orthogonal to
3 the first pivot axis.

1 8. The fast steering mirror of claim 7, wherein the mirror is disposed relative to
2 the inner gimbal such that that mirror contain a common point on its surface through
3 which both the first and second pivot axes pass.

1 9. The fast steering mirror of claim 1, wherein the outer gimbal is pivotally
2 coupled to the base member via a pair of flex pivots.

1 10. The fast steering mirror of claim 1, wherein the inner gimbal is pivotally
2 coupled to the base member via a pair of flex pivots.

1 11. The fast steering mirror of claim 1, wherein the base member comprises:
2 a base having an upper surface to which the first and second pairs of
3 magnetized stators are fixedly coupled; and
4 a frame, having a bottom surface fixed coupled to the upper surface of the
5 base and having a pair of supports extending upward from opposite corners
6 therefrom to which the outer gimbal is pivotally coupled.

1 12. The fast steering mirror of claim 1, further comprises a driver board
2 containing drive circuitry to provide drive currents to drive the first and second pairs
3 of voice coils and means for electrically connecting each of said drive currents to a
4 respective voice coil.

1 13. The fast steering mirror of claim 12, wherein each of the first and second
2 pairs of voice coils are configured such that the drive current for one voice coil in
3 each pair of voice coils generates magnetic lines of flux that have a direction that is
4 opposite to the magnetic lines of flux for the other voice coil in the pair.

1 14. The fast steering mirror of claim 1, further comprising an optical-based
2 feedback and control mechanism to enable the mirror to be positioned in a
3 reference position.

1 15. A fast steering mirror, comprising:
2 a base member;

an outer gimbal, pivotally coupled to the base member;
an inner gimbal, pivotally coupled to the outer gimbal;
a mirror fixedly coupled to the inner gimbal;
a first pair of voice coil drivers comprising a first pair of magnetized stators fixedly coupled to the base member and a first pair of voice coils fixedly coupled to the outer gimbal; and
a second pair of voice coil drivers comprising a second pair of magnetized stators fixedly coupled to the base member and a second pair of voice coils fixedly coupled to the inner gimbal;
a control system configured to receive a position feedback signal and generate drive currents in response thereto to drive each of the voice coils in the first and second pairs of voice coils to control a position of the mirror; and
means for connecting drive current outputs of the control system to each of the voice coils in the first and second pairs of voice coils.

16. The fast steering mirror of claim 15, wherein the control system includes programmed logic comprising an algorithm that determines a positional error based on the position feedback signal and generates appropriate drive currents to adjust the position of the mirror such that the positional error is reduced.

17. The fast steering mirror of claim 16, wherein the algorithm is processed using a digital signal processor (DSP).

18. The fast steering mirror of claim 16, wherein the DSP is contained on a circuit board that is external to the fast steering mirror, further comprising a computer interface that enables signals to be communicated between the circuit board and the

4 fast steering mirror over a cable connected between the circuit board and the fast
5 steering mirror.

1 19. The fast steering mirror of claim 15, wherein the control system includes a
2 printed circuit board operatively coupled to the base member that includes
3 amplification circuitry to drive the voice coils.

1 20. The fast steering mirror of claim 15, further including:
2 a reflector, coupled to a backside of the mirror;
3 an emitter to emit light that is directed toward the reflector; and
4 a light beam position detector; receiving a portion of light reflected from the
5 reflector,
6 wherein the control system includes a reference positioning mode that uses a
7 feedback signal produced by the light beam position detector in response to the
8 portion of light it receives to position the mirror in a reference position.

1 21. The fast steering mirror of claim 20, further including a lens disposed
2 between the reflector and the light position detector to focus light reflected by the
3 reflector onto the light beam position detector.

1 22. The fast steering mirror of claim 20, further including a pin-hole aperture
2 disposed between the emitter and the reflector to direct a portion of the light emitted
3 by the emitter toward the reflector.

1 22. The fast steering mirror of claim 15, wherein the means for connecting the
2 drive current outputs of the control system to each of the voice coils comprises flex
3 circuits.

1 23. The fast steering mirror of claim 15, wherein each of the first and second
2 pairs of voice coils includes windings that are connected in series such that a
3 current flowing through the windings causes one of the voice coils in a pair to
4 generate a push force away from its corresponding magnetic stator while the other
5 voice coil in the pair generated a pull force toward it corresponding magnetic stator.

1 24. The fast steering mirror of claim 15, wherein each of the voice coils in said
2 first and second pair of voice coils comprises a cylindrical shell-shaped bobbin
3 having a plurality of conductive coils wound around an external portion thereof.

1 25. The fast steering mirror of claim 15, wherein each of the magnetized stators
2 in said first and second pair of magnetized stators comprises a generally can-
3 shaped member made of a magnetically permeable material in which an annular
4 magnet is disposed.

1 26. The fast steering mirror of claim 25, wherein the generally can-shaped
2 member further comprises an internal post extending upward from a base portion
3 thereof.